## Remarks

Reconsideration and withdrawal of the outstanding rejections and objection and early allowance of the above-identified application is respectfully requested.

A minor, formal revision on page 18 of the Specification was implemented, thereby rendering moot the outstanding objection thereto.

With the above-made amendments, also, claims 1-4 and 6-34 are now pending, of which claims 1, 6 and 24 are currently amended and claims 26-34 are being newly presented. Claims 13-23 stand withdrawn from purposes of examination as a result of an earlier Restriction Requirement.

Base claim 1 was amended for purposes of clarifying the invention set forth therein including in terms of avoiding the matters raised in item 5, on page 3 of the outstanding Office Action. For example, claim 1 now specifically sets forth " a method ..." in which the set forth language following "the improvement" relates to the "method." Accordingly, since any previously outstanding question of definiteness has now been overcome, the rejection of claims 1-12 under 35 USC §112, second paragraph, is traversed and reconsideration and withdrawal of the same is respectfully requested.

Independent claim 1 was amended, also, in a manner to associate <u>the relating of at least one physical parameter to scattering caused by interband states</u> to an improved model, for example, <u>a model which takes into account transition between a band and interband states in a band gap of the film.</u> This

addresses the discussion with regard to Fig. 1 of the drawings, the discussion on page 4, line 17, to page 5, line 13, and on page 9, line 16+, *et seq.*, and relates also to the discussion of the "quantum mechanical transition equation for transitions between at least one of valence and conduction bands and interband states in a band gap" (see claim 6). The discussion leading up to the equations 4 and 5 in the Specification which takes into account the referred-to "anomalous variations" in the physical parameters such as very large sudden increases followed by a decrease of the, for example, refractive index or reflectances, such as discussed with regard to Fig. 2 of the drawings, is also related thereto.

Since the set forth "model" in claim 5 is now contained in base claim 1, claim 5 has been accordingly canceled. Correspondingly, the dependency of claim 6 has been changed so as to now be dependent on base claim 1, in view of the canceling of claim 5.

Regarding the set forth "apparatus" in independent claim 24, it has now been amended so as to highlight therein also that the model "[takes] into account transition between a band and interband states in a band gap of the film." This featured aspect is similar to that incorporated in independent claim 1.

Newly added dependent claims 26 and 27, which are combined with independent claim 24, respectively, set forth the further limiting aspects contained in claims 3 and 4. Newly added dependent claim 28 further

characterizes the "model", according to the set forth apparatus in claim 24, as being "characteristic of the film over a wide range of wavelengths including in the UV wavelength range." Such is now also set forth with regard to newly added claim 29 which further defines the method of calculating according to claim 1. Supportive discussion directed thereto is found on page 4, line 17, *et seq.,* in the Specification.

Claims 30-34 were also added. Claim 30 is based on subject matter contained in independent claim 24 using, instead, "means" language. As an added alternative, also, independent claim 31 is being submitted using accepted Beauregard claim language construction. New claim 32, dependent on claim 31, limits the physical property to an optical property. New claims 33 and 34, both also dependent on claim 31, characterize the set forth "at least one physical property" to that of claims 3 and 4, respectively. It is submitted, the invention as now set forth in claims 1+, 24+, 30 and 31+ is a clear and patentable improvement over that previously known including over the art documents as cited in the outstanding rejections.

Claims 1-6, 11 and 12 were rejected under 35 USC §103(a) over the combination of Jellison, Jr., et al ("Parameterization of the Optical Functions ... Interband Region") in view of Adachi ("Optical Dispersion Relations for Si and Ge") and further in view of Halliyal et al (USP 6,563,578 B2); claims 7-10 were rejected under 35 USC §103(a) over the same combination of Jellison, Jr., et al in view of Adachi and Halliyal et al and further in view of "the disclosure

of the applicant;" and claims 24-25 were rejected under 35 USC §103(a) over Zawaideh (USP 5,999,267) in view of the combined teachings of Jellison, Jr., et al, Adachi and Halliyal et al. It will be shown, hereinbelow, the invention according to claims 1-5, 7-12, 24-34 could not have been realized over the combined teachings as alleged in the outstanding rejections. Therefore, these rejections, insofar as presently applicable, are traversed and reconsideration and withdrawal of the same are respectfully requested.

The invention according to <u>claims 1+ calls for an improved method of calculating at least one physical parameter of a film which uses a model for relating the physical parameter(s) to be calculated to scattering caused by interband states, the model taking into account transition between a band and interband states in a band gap of the film</u>. The invention according to claims 24+, which set forth an apparatus, likewise, uses a theoretical model for calculating similarly to that in claim 1.

According to an aspect thereof, the model includes a *quantum mechanical transition equation for transition between at least one of valence and conduction bands and interband states in a band gap* such as that set forth with regard to claims 6-8. Further, the "model" can be used for calculating the refractive index (n) and the extinction coefficient (k) equations such as set forth with regard to claim 9. In accordance with the present invention, measured data of an optical property of the film such as for obtaining the fitted parameters may be obtained from a reflectometer or an ellipsometer (see claim

10). The method and apparatus which employs the model can be used to calculate the refractive index and the extinction coefficient of the film (see claims 3, 4 and 9 as well as claims 26-27). The film according to the present invention is applicable, for example, for semiconductor and dielectric film materials such as those having varying levels of interband states.

The model according to the present invention overcomes the limitations of other empirical models, such as the Cauchy empirical model referred to on page 4, line 8+, and on page 9, line 1 *et seq.,* in connection with explaining very large increases followed by decreases with regard to the, for example, refractive index or reflectance, such as described with regard to Fig. 2 of the drawings, as the wavelength approaches the absorption band from the long-wavelength side and then decreases within the band to assume abnormally small values on the short-wavelength side. The referred to "anomalous variation" can be explained with regard to models set forth according to the method and apparatus therefor of the present invention.

The set forth "model" relates the physical parameter(s) to scattering caused by interband states, this being done through taking into account transition between a band and interband states in a band gap of a film (e.g., see Fig. 1) to calculate the imaginary part $\epsilon_2(\omega)$ as well as the real part $\epsilon_1(\omega)$ of the dielectric film which are given by equations (4) and (5), on page 11 of the Specification. It should be noted, the model which sets forth the equation according to claim 8, which is based on the derived equation (5) on page 11 of

the Specification, takes into consideration transitions between a band such as the valence and/or conduction band with that of interband states such as that associated with energy level $E_D$ in Fig. 1, in clear contradistinction with that taught even in view of the combined teachings of the cited references.

Also according to the present invention, the effect of the scattering caused by interband states in the formulation of the model according to claim 1 is also taken into consideration in formulating the relationships for the calculating of the physical parameters refractive index (n) and extinction coefficient (k) of the film such as set forth in claim 9 (see page 12, lines 1 *et seq.,* of the Specification). It is submitted, such a scheme as that now set forth in claims 1+ and, likewise, in claims 24+, 30 and 31+ could not have been rendered obvious as that alleged in the related rejections.

Jellison, Jr., et al disclosed a method of parameterization of optical functions of amorphous semiconductors and insulators. In their model, the imaginary part of the dielectric function $\epsilon_2$ is determined by multiplying the Tauc joint density of states by the $\epsilon_2$ obtained from the Lorentz oscillator model. Jellison, Jr., et al employed the Kramer-Konig integration relation (see equation (5) on page 372 in Jellison, Jr., et al, in which P represents the Cauchy principle part of the integral). This relation is similar to the Kramer-Konig relation shown on page 11, which precedes the equation of the "model" according to the present invention, which takes into account the transition between a band and an interband state in a band gap of the film, such as

discussed earlier in these remarks and as more clearly explained in the present Specification.

In the models disclosed by Jellison, Jr., et al, none of the equational relationships, it is believed, correspond to the "model" set forth in claims 1+, 24+, 30 and 31+ of the present invention. In the TL model (which is based on the Tauc joint density of states and the Lorentz oscillator), according to Jellison, Jr., et al, the "parameterization includes only interband transitions" (see page 373, col. 2, lines 7-9), unlike that according to the "model" of the present invention which relates the physical parameter(s) to scattering caused by interband states, taking into account transition between a band and interband states in a band gap of the film. The equational relationships associated with the calculating of the physical parameters such as the refractive index (n) and extinction coefficient (k) of the film (see claim 9) using the values for $\epsilon_1(\omega)$ and $\epsilon_2(\omega)$ obtained in accordance with the "model" of the present invention also yields a different relationship from that of the applied art. It is evident, Jellison, Jr., et al, did not take into account the "anomalous variations" discussed earlier in these remarks which have led them to scheme a model which relates the physical parameters to scattering caused by interband states, taking into account the transitions between a band and interband states in the band gap of the film nor the specific equation relations such as that set forth in claims 6+.

Adachi is also deficient in terms of the present claimed subject matter. Adachi disclosed a scheme for calculating optical constants such as the refractive index, extinction coefficient, absorption coefficient, and normal-incidence reflectivity of silicon (Si) and Germanium (Ge) material. In his analysis, Adachi used the energy-band structures of materials to formulate his model for calculating the refractive index, extinction coefficient, and the normal-incidence reflectivity. Although Adachi mentions "indirect-band-gap transitions," there does not appear to be any teaching therein of modeling the parameterization to the scattering caused by interband states, taking into account the transition between the band and interband states in the band gap of the film, for example, transitions between at least one of the valence and conduction bands and interband states in a band gap of the film. This is also evidenced by the fact that the equational relationships of the "model" such as set forth in claims 7, 8 and 9 of the present invention, are also formulated differently from that of Adachi.

Halliyal et al disclosed a system and method for providing *in-situ* monitoring of thin film thickness through employing optical measurement schemes. In the referred to optical system 100, shown in Fig. 6 of Halliyal et al, the optical properties of the reflected beam 114 relative to the properties of the incident light beam 112 are used to determine the thickness of the thin film 102. According to Halliyal et al, optical properties generally depend on the index of refraction, absorption constant and the thickness of the film. (Col. 10,

lines 23-24, in Halliyal et al.) However, Halliyal et al, it is submitted, did not appear to take into consideration the "anomalous variations" nor formulate a model for relating the physical parameters to scattering caused by interband states taking into account transitions between a band and interband states in a band gap of the film, such as that discussed with regard to the showings in Figs. 1 and 2 of the drawings of the present application. In accordance with the present invention, the theoretical model, which features a quantum mechanical transition equation which takes into account transitions between the valence and/or conduction bands and interband states in the band gap of the film, leads to different equational relationships from that previously known. Therefore, the method for calculating according to claims 1+ could not have been rendered obvious in a manner as that alleged with regard to the rejection of claims 1-5 and 7-12, as presently amended.

Reconsideration and withdrawal is also respectfully requested with regard to the outstanding rejection based on Zawaideh as combined with the above-discussed references, including Jellison, Jr., et al, Adachi and Halliyal et al, insofar as applicable to the currently pending claims 25-28. The invention according to independent claim 24 sets forth an apparatus which includes:

> an **optical instrument** for measuring an optical property of a film containing interband states and producing measured data as a result of the film measuring; and
>
> a **program computer** for calculating at least one physical parameter of the measured film using the measured data and theoretical model relating the physical parameter to scattering caused by interband states, the model

taking into account transition between a band and interband states in a band gap of the film.

An example of this is disclosed with regard to Fig. 4 of the drawings, in which the apparatus features an optical instrument 7, which may be a reflectometer and/or ellipsometer, for measuring a film in which an alien species has been introduced or a film otherwise treated to have varying concentrations of interband states and for producing measured data as a result of the film measuring. Also according to this embodiment, the device features a program processor 8 which calculates one or more physical parameters of the measured film and displays it at display 9 using the measured data and a theoretical model relating the physical parameter to scattering caused by interband states in the film, the model taking into account transition between a band and interband states in a band gap of the film. (Page 15, line 9, etc., of the Specification, as well as Figs. 4-7 thereof.)

Zawaideh disclosed a scheme which uses the "concept of relative shift (ratio) of power spectral density as a function of incident angle to simultaneously measure optical constants and thickness of single and multi-layer films... ." (Column 1, lines 53-59, in Zawaideh.) Zawaideh disclosed a model which is described in connection with Figs. 1 and 2 of the drawings. In accordance with the measurement model, the scheme measures reflectance (or transmittance) for normal and oblique angles of incidence over a wide spectral range using a spectrophotometer (e.g., detectors 12, 16) and as described with

regard to Fig. 2 thereof, the method determines the optical constants including the coefficient of refraction (n) and the extinction coefficient (k) and thickness of the single/multilayer films 13. However, Zawaideh failed to overcome the deficiencies discussed above with regard to the other cited references, each taken separately or, for that matter, combinedly. In this respect, it is noted that Zawaideh refers to Jellison, Jr., et al's model which employs a general dispersion formula for describing the optical constants n, k in the measured wavelength range. (Col. 4, lines 33-39, in Zawaidah.) As was shown earlier, Jellison's model, it is submitted, did <u>not</u> relate the physical parameter(s) to scattering caused by interband states, taking into account also the transition between a band and interband states in the band gap of the film. Therefore, notwithstanding Zawaideh's schemed apparatus, Zawaideh, likewise, does not overcome the limitations of Cauchy's empirical model, which is referred to earlier in these remarks and is discussed more extensively in the present Specification. For at least the above reasons, the invention according to independent claim 24 and further according to the corresponding dependent claims thereof and, likewise, the "means" language and Beauregard claim construction counterparts, according to claims 30 and 31+, could not have been rendered obvious in a manner as that alleged in the outstanding rejections.

Therefore, in view of the amendments presented hereinabove together with these accompanying remarks, reconsideration and withdrawal of the outstanding rejections as well as favorable action therefor on the claims and an

early formal notification of allowability of the above identified application is respectfully requested.

To the extent necessary, applicants petition for an extension of time under 37 CFR §1.136. Please charge any shortage in the fees due in connection with the filing of this paper, including Extension of Time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Dep. Acct. No. 01-2135 (178.39931X00), and please credit any excess fees to such deposit account.

Respectfully submitted,
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